



Contact Angle Measurements – Sliding Angle Method

The DM-701, a fully automatic contact angle meter with a rotating base, manufactured by Kyowa Interface Science Co., Ltd., is capable of measuring the sliding angle of a droplet on a surface via automated rotation of the entire measuring unit. The DM-701 can rotate under software control to any angle from 0° to 90° continuously or intermittently. The stage, light source and capturing camera all rotate simultaneously as one unit. This is advantageous over a stage-rotating setup where only stage is rotated. When only stage undergoes rotation and the camera and light-source are in stationary, the rotated stage may block some of the field of view of the camera, and it may also cause the illumination conditions to change. These disadvantages associated with the stage-only rotation setup could lead to contact angle measurement errors at different rotation angles. On the other hand, the DM-701 has no such concerns at all.

Sliding angle that may also be called roll-off angle has its own practical meaning and usefulness. It is defined as the angle between the sample surface and the horizontal plane at which the liquid drop starts to slide off the sample surface under gravity influence. Its simply conceivable applications are in windshield and building roof designs. The slope and material choices in designs ought to be in favor of rain drops' rolling off. The angles of the surfaces relative to the ground should be at least larger than the water sliding angles on the surfaces of the windshield and roofing materials.



Figure 1. Captured image of a droplet undergoing sliding during intermittent rotation used for sliding angle analysis of an extruded plastic tube.

The advancing and receding angles can also be determined by the sliding angle method. The advancing and receding angles are the liquid drop front and rear end contact angles respectively at the drop slide starting point. The sliding angle method for advancing and receding angle measurements has the advantage of not having the dispenser tip in contact with the droplet over



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the extension and contraction method. By being out of contact with the droplet, the tip is cleared from any potential influence for the advancing and receding angle measurement. The work of adhesion between liquid and the solid surface can also be determined through the sliding angle method.

The DM-701 can measure the sliding angle by intermittently or continuously rotating the whole contact angle measurement unit. Under the intermittent mode, the unit rotates one degree at a time, holds and rotates again. The boundary and position of the droplet are compared to the boundary and position at starting point to determine if the droplet has moved. Under continuous mode the unit rotates at a fixed speed while the images are taken and compared at a selected frame rate. The DM-701 has a 60 frames per second capture rate that is sufficient to record virtually all transit events during the sliding angle method execution. Due to the direction of unit rotation, the advancing and receding angles are determined at the left (lower) side and right (upper) side of the droplet respectively.

As an example, a series of sliding angle measurements were performed on an extruded plastic tube with the DM-701 using distilled water. A droplet size of 10 μ L was used. After depositing a droplet on the tube sample surface, the intermittence tilt method was used in this example. The intermittence tilt rotates the measuring unit including the stage with the sample one degree and holds the unit there for a given amount of time. The system takes an image at the start of the hold and another at the end of the hold. Once it finishes this task, the stage rotates one degree again and repeats the process until the rotation reaches the pre-set angle or being aborted for any reason.

The image in Figure 1 shows a droplet had underwent sliding transition. Since the sample on the stage rotated together with the camera and the lamp as a whole unit, the image appears flat in Figure 1. The image was actually taken at a sample surface tilt angle relative to the horizontal plane. The different front and rear end contact angles indicated the rotation and were used for determining the advancing and receding angles. Table 1 summarizes the numerical experimental results that were obtained via the sliding angle method on the extruded plastic tube sample.

Table 1 Sliding Angle Measurement Results Obtained on an Extruded Plastic Tube Surface using Distilled Water

Measurement	Average	Standard Deviation
Sliding Angle (°)	31	2
Advancing Angle (°)	116.1	1
Receding Angle (°)	96.5	2.3
Adhesive Energy (mJ/m ²)	5.5	0.3